INTRODUCTION TO TANK VESSELS

Objectives

To successfully complete this assignment, you must study the text and master the following objectives:

- **IDENTIFY** the three basic types of tank vessels.
- **IDENTIFY** the arrangement of tanks on a tank ship.
- **IDENTIFY** the tank arrangements commonly found on tank barges.
- **DEFINE** the following classifications used for bulk liquid cargoes:
  - flammable liquids
  - combustible liquids
- **IDENTIFY** the basic cargo systems found on board tank vessels.
- **IDENTIFY** some basic cargo tank characteristics found on LNG/LPG carriers.

References

The information contained in this lesson can be found in the following references:

- 46 CFR 1 – 40, 151, and 154
- COMDTINST M16000.7, MSM VOL II

Resident Training Requirements

This lesson covers the following performance qualifications for the following resident training courses:

MIC

OVERVIEW

Introduction

This lesson will serve as an introduction to tank vessels. This information should be useful if you board these types of vessels in the field.

Outline

In this lesson we are going to discuss:

- **Tank Vessels**

  tank ship
  tank barge

- **Tank Ships**

  cargo tank arrangement
  cargo tanks

- **Tank Barges**

  tank barge classification
  cargo tank arrangement
  cargo tanks

- **Classification of Bulk Liquid Cargoes**

  flammable liquids
  combustible liquids

- **Basic Tank Vessel Cargo Systems**

  piping systems
  pumping systems
  venting systems
  gauging systems
  firefighting systems
  inert gas systems

- **LNG/LPG Carriers**

  cargo tanks

TANK VESSELS

Introduction

There are three basic types of tank vessels:

- Tank ships
- Tank barges
- LNG/LPG carriers

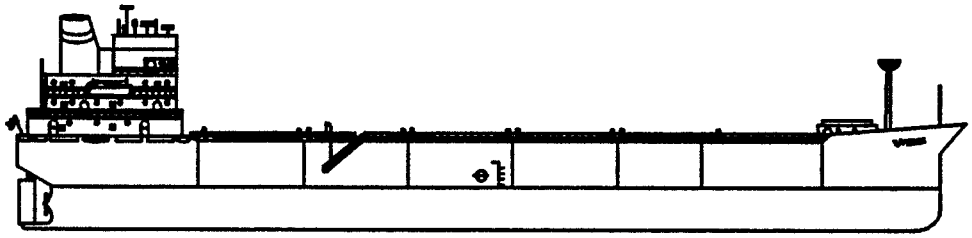
Tank Ship

A tank ship is a self–propelled vessel designed to carry bulk liquid cargoes. There are three types of tank ships:

- Crude oil tankers – vessels which carry large quantities of crude oil. These vessels are the largest tankers some in excess of 1200 feet.
- Product Carriers – vessels which carry petroleum products other than crude oil.
- Chemical tankers – vessels which carry a number of different chemical products or hazardous materials at the same time in relatively small quantities. These are normally small tankers.

Illustration

This is an illustration of a tank ship.

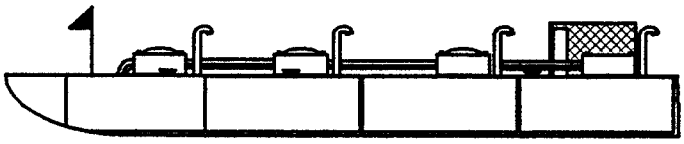


Tank Barge

A tank barge is a vessel designed to carry bulk liquid cargoes. It is normally pushed from place to place by a tow boat.

Illustration

This is a illustration of a tank barge.



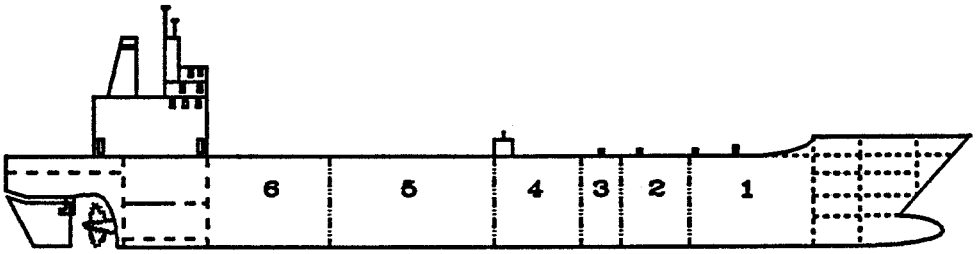
TANK SHIPS

Introduction

Tank ships are designed to carry cargo in bulk form. Virtually the entire vessel has tank spaces for carrying cargo, fuel oil, or ballast. Because of the potential hazards associated with them (i.e., fire, explosion, or pollution), tank ships are designed and constructed with special features to safely load, carry, and off–load their cargo.

Illustration

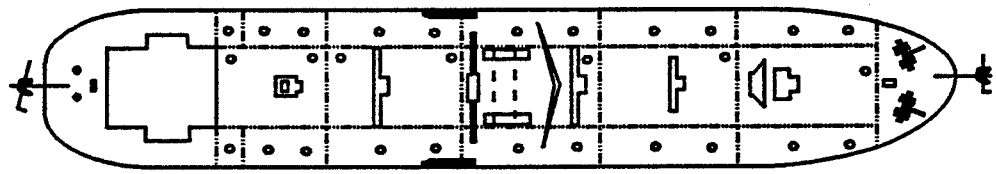
This is an illustration of the tank arrangement and profile. The numbers correspond with the tanks:

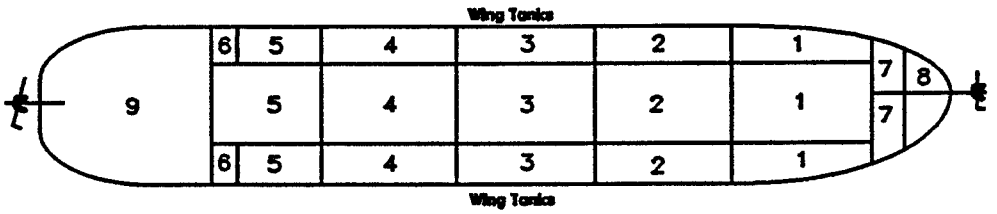


Cargo Tank Arrangement

The arrangement of cargo tanks on most tankers is similar. Most have a series of five or six port, center, and starboard tanks extending from the bow aft toward the superstructure and pump room. Clean ballast tanks are usually located in the wing tanks for added stability and cargo tank protection.

MAIN DECK VIEW





TANK ARRANGEMENT

1. No.1 Cargo Tank, port, center, starboard
2. No.2 Cargo Tank, port, center, starboard
3. No.3 Cargo Tank, port, center, starboard
4. No.4 Cargo Tank, port, center, starboard
5. No.5 Cargo Tank, port, center, starboard
6. Side Bunkers
7. Forward Deep Tanks
8. Forepeak (water ballast)
9. Engine Room

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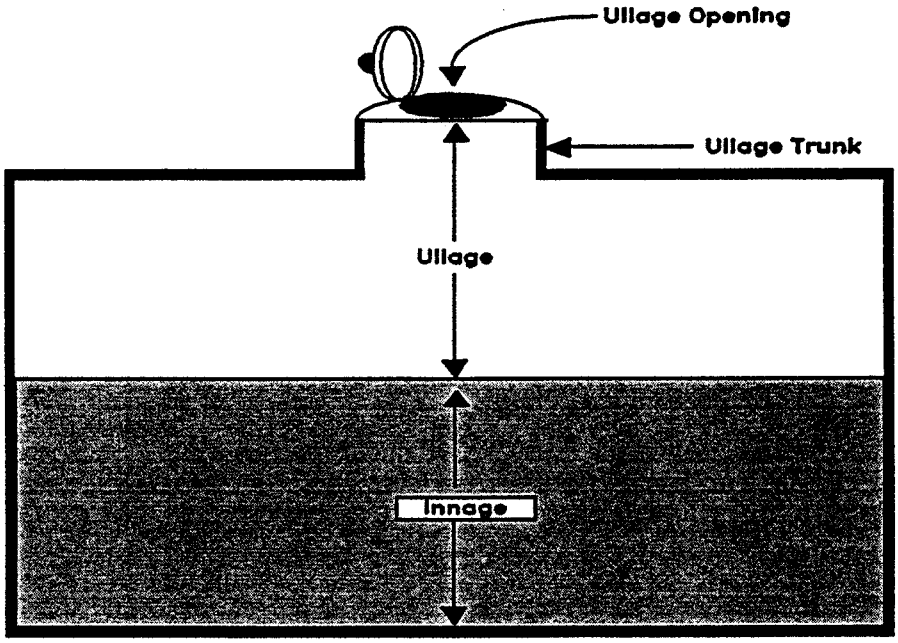
Cargo Tanks

Products carried on board tank ships are carried in cargo tanks. These tanks can be quite large and are usually constructed of steel. Each cargo tank usually has an opening at the main deck called an "ullage opening." Ullage openings are normally used to measure or gauge the amount of cargo in the tank.

Note: Gauging will be covered later in this lesson.



CARGO TANK TERMINOLOGY

Ullage also means that part of the cargo tank which does not contain liquid cargo as indicated in the illustration. Ullage is measured from the surface of the liquid to the tank top. Ullage may also be called "outage."

Innage is the amount of cargo in the tank. It is measured from the surface of the liquid to the tank bottom.

TANK BARGES

Introduction

Tank barges are also designed to carry cargo in bulk form. Most tank barges differ from tank ships because they have no propelling machinery or living spaces.

Tank barges are commonly found on inland waterways and are designed to carry a variety of bulk liquid cargoes. Tank barges range in length from less than 100 to several hundred feet.

Tank Barge Classification

There are three basic hull type classifications. The classifications are based on the degree of protection the hull provides to the environment. They are:

- Type I Barge Hull. Type I hulls are those designed to carry products which require the maximum preventive measures to preclude the uncontrolled release of the cargo to the water or atmosphere.
- Type II Barge Hull. Type II hulls are those designed to carry products which require substantial preventive measures to preclude uncontrolled release to the atmosphere, but whose uncontrolled release to the waterways does not constitute a long lasting public or operating personnel hazard, though local and temporary pollution may occur.
- Type III Barge Hull. Type III hulls are those designed to carry products of sufficient hazard to require a moderate degree of control.

The following are examples of cargoes and their barge hull types:

BARGE TYPE	DEGREE OF CONTAINMENT	TYPICAL CARGOES
I	Maximum	Chlorine Ethylene oxide Liquefied natural gas (LNG) Motor fuel antiknock compounds
II	Substantial	Liquefied petroleum gases Anhydrous ammonia Camphor oil Ethyl ether Vinyl chloride
III	Moderate	Most acids Carbon tetrachloride Chloroform Some petroleum products

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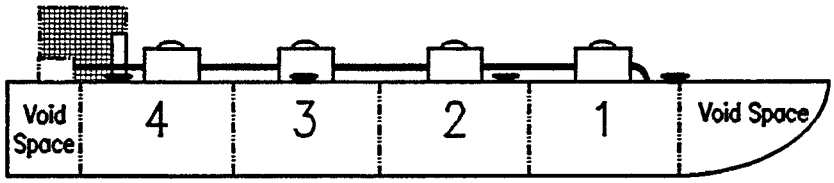
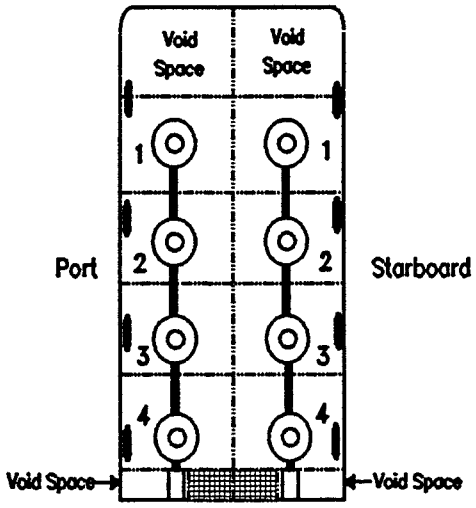
TANK BARGES (CONT.)

Illustration

This is an illustration of a Type III tank barge arrangement and profile. The numbers correspond with the tanks:



SIDE VIEW



TOP VIEW

The simplest type of tank barge is a simple box divided by a longitudinal centerline bulkhead and by several transverse bulkheads. All bulkheads are oiltight, so that the barge is divided into a number of separate cargo tanks. The end spaces are left void (i.e., empty), providing buoyancy when cargo tanks are full.

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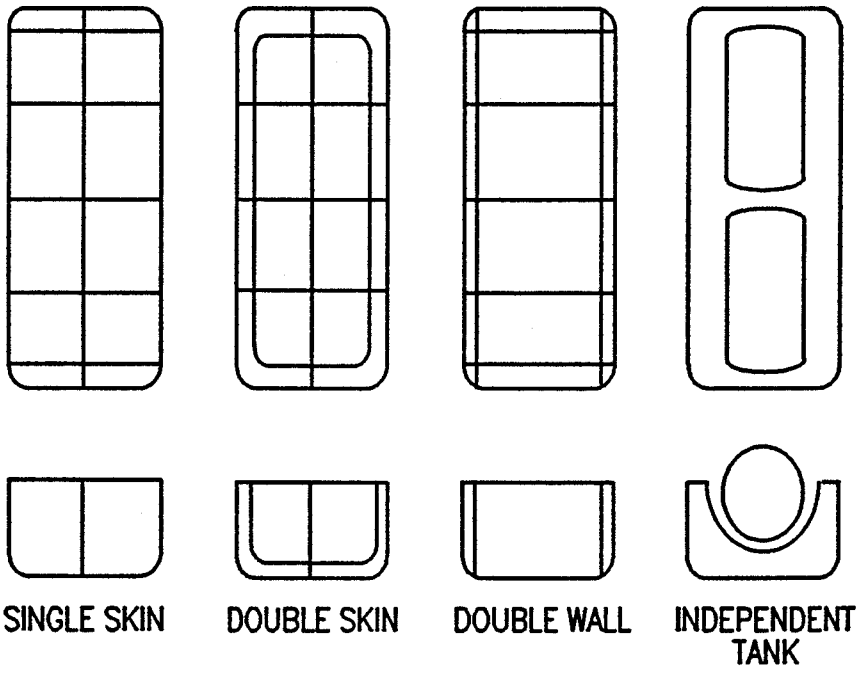
TANK BARGES (CONT.)

Cargo Tank Arrangement

Besides the hull type classifications, there are also a number of common variations for tank barge cargo tank arrangements. There are four distinct cargo tank arrangements:

- Single skin
- Double skin
- Double wall
- Independent tank



A **single skin** tank barge is divided into cargo tanks by a number of transverse bulkheads and may also have a centerline bulkhead running fore and aft. Only the steel shell or single skin separates cargo from the water. This type of arrangement is allowed only in Type III barges.

Double skin tank barges have void spaces around the cargo tank sides and bottom. There are double skin barges for Type I, II, and III barges. Double skin provides protection against cargo spills in case of grounding or collision.

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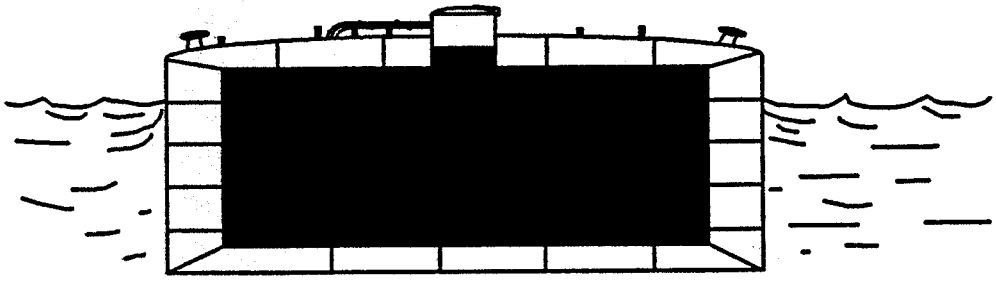
Cargo Tank Arrangement (cont.)

Double wall tank barges have void spaces along their sides (walls). They do not have double bottoms. These type of barges provide protection against collision but no added protection against groundings.

Note: Single skin, double skin, and double wall barges have integral tanks. In an integral tank, the tank structure is an essential part of the structure of the barge. This means that the tank is rigidly attached to the barge throughout its length in such a manner that the tank contributes to the strength of the barge.

INTEGRAL TANK

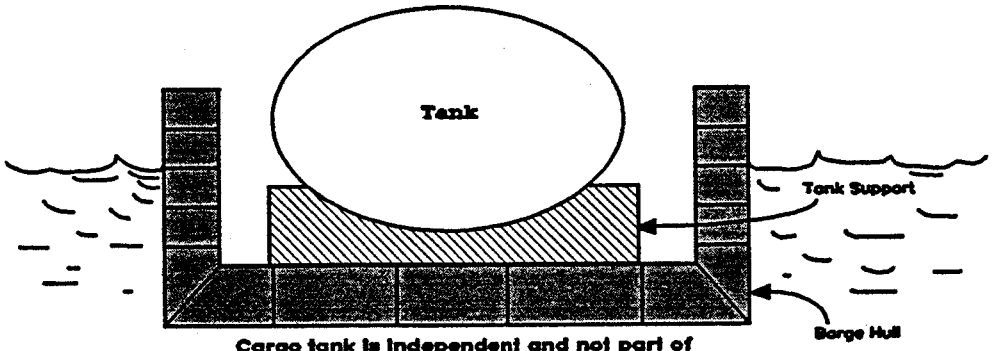


Tank structure is part of the vessels structure

The **independent tank** barge differs from the other three because its cargo tanks are not designed as part of the hull structure. The cargo tanks are built separately and are installed into the barge hull after it is constructed.

The independent tank or tanks are carried in the barge which have been fitted with special saddles or supports shaped to hold the tanks.

INDEPENDENT TANK



Cargo tank is independent and not part of the vessels structure

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TANK BARGES (CONT.)

Cargo Tanks

There are several hundred regulated bulk commodities that are carried by tank barges. For each commodity a tank type is specified. Cargo tank types may be identified by:

- their shape or geometry (e.g., rectangular, hull–shaped, spherical)
- the pressure of contents (e.g., gravity–not more than 10 psig)
- the way they are built (e.g., integral, independent)

They also may be identified by:

- temperature (e.g., low temperature, ambient temperature, heated)
- their internal coatings (e.g., lined, clad, coated, uncoated)

There are also cargo tanks that are required to be insulated. Insulated tanks are needed for cargoes carried at very low temperatures, such as liquefied natural gas. Insulated tanks are also needed for cargoes that are carried at very high temperatures too, such as asphalt, molten sulfur or phosphorus.

Insulation is required around these cargoes both to retard heating or cooling of the cargo and to protect personnel.

CLASSIFICATION OF BULK LIQUID CARGOES

Introduction

Tank vessels are inspected and certified to carry flammable or combustible liquids in bulk.

In 46 CFR Subchapter D – Tank Vessels (parts 30–40), there is a table (Table 30.25–1) that lists all the cargoes that are found to be flammable or combustible and may be transported in bulk.

When a tank vessel is certified to carry flammables or combustibles, their Certificate of Inspection states the grade(s) of cargoes that may be carried. There are five separate grades for flammables and combustibles. They are identified in this lesson.

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CLASSIFICATION OF BULK LIQUID CARGOES (CONT.)

Flammable Liquids

Flammable liquids are those which give off flammable vapors at or below a temperature of 80°F. Within this class, there are three grades based on Reid vapor pressure and flash point.

- Grade A cargoes are those having a Reid vapor pressure of 14 psi or more. Examples are: Butylene, Pentane.
- Grade B cargoes are those having a Reid vapor pressure over 8½ psi and under 14 psi. An example is: iso–Hexane.
- Grade C cargoes are those having a Reid vapor pressure of 8½ psi or less and a flash point of 80°F or below. Examples are: Acetone, Ethyl Acetate, Gasoline.

Note: Reid vapor pressure is the equilibrium pressure exerted by vapor over liquid at 100°F, expressed in pounds per square inch absolute and defined in 46 CFR 30.10–59.

Combustible Liquids

Combustible liquids are those which give off flammable vapors at temperatures above 80°F. Within this class there are two grades, based on flash point:

- Grade D cargoes are those having a flash point above 80°F, but below 150°F. Examples are: n–Butyl Acetate, iso–Butyl Alcohol, Kerosene.
- Grade E cargoes are those having a flash point of 150°F or above. Examples are: Bunker C, Caster Oil, Cottonseed Oil.

BASIC TANK VESSEL CARGO SYSTEMS

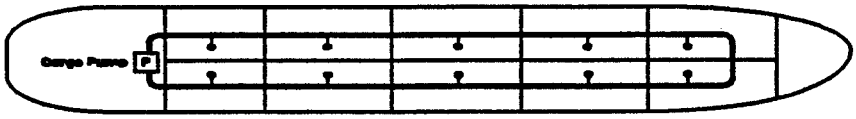
Introduction

In order to safely load, carry, and off–load its cargo, tank barges are equipped with systems that help ensure this happens. The basic systems addressed in this lesson are common with all tank vessels carrying bulk regulated commodities.

Piping Systems

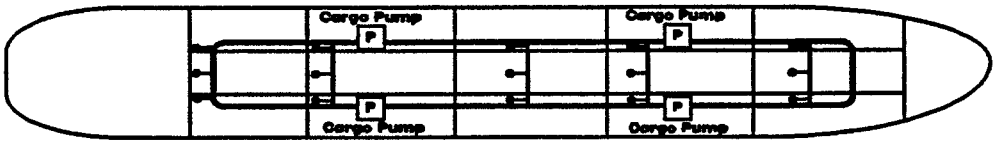
Cargo is transported on and off tank vessels through piping systems. Cargo is also moved to and from the cargo tanks within a vessel through a series of pipes.

On tank vessels part of the piping system is exposed on the main deck and some of the piping system is built within the vessel. In a simple system each cargo tank is connected by a common series of pipes. This type of system is commonly used on tank vessels which always carry the same product.

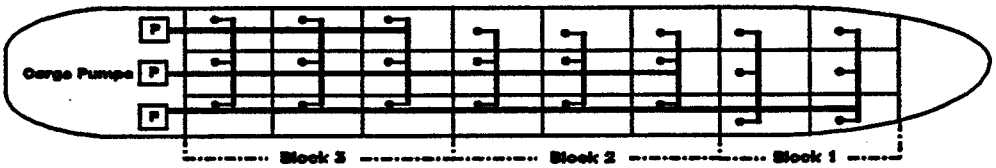


Common system with single pump. All liquids pumped through the same pipes.

On chemical carriers, piping systems can be very complex where each tank, or a series of tanks, uses a separate piping system. These types of piping systems are mandatory for quality control of the cargo and safety issues. If two incompatible cargoes came in contact with each other, they could react and possibly endanger the vessel or vessel personnel.



Piping system for multi cargoes which can be pumped independently.



Piping system for three blocks of tanks. Each block is served by its own piping.

Also, just like cargo tanks, some piping systems are insulated for those cargoes that are carried at very low or high temperatures.

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Pumping Systems

Tank vessels are equipped with cargo pump(s) which are used to move cargo through the piping systems you just learned about.

Cargo pumps are classified in two different ways. They are either:

- positive–displacement (e.g., piston or gear pumps)
- continuous–flow (e.g., centrifugal pumps)

Tank vessels primarily use centrifugal pumps because they are less expensive and provide greater reliability. They also provide a uniform and steady flow and their pumping capacity can be easily increased or decreased.

Venting Systems

Tank vessel cargo tanks are provided with vents to avoid excessive pressure or vacuum within the closed tank. These vents penetrate the tank at its uppermost boundary to provide for positive venting.

There are three common types of venting systems found on board tank vessels. They are:

- gooseneck vent
- pressure–vacuum (PV) relief valve
- safety relief (SR) valve

Gooseneck vents are considered an "open venting" system. This type of vent allows vapor to flow freely to and from the tank. Gooseneck vents are only authorized when the least dangerous cargoes (Grade D and E) are carried. Gooseneck vents must be fitted with an approved flame screen.

Note: A flame screen is a finely meshed screen which will permit the passage of air and vapors but will prevent a flame from being drawn into a tank – but only if the screen is properly maintained and free of holes.

PV relief valves are normally considered a "closed venting" system. They are designed to open under a preset positive pressure or vacuum. PV relief valves are normally required for flammable liquids (Grades A, B, and C). This type of vent is required to be fitted with a flame screen too.

SR valves are also considered a "closed venting" system. They are designed to open under a preset positive pressure. SR valves are normally required for pressurized cargoes. For example: you would normally see SR valves at the top of a cargo tank on a tank barge carrying propane in independent tanks.

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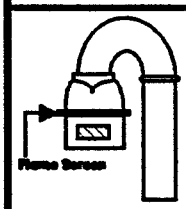
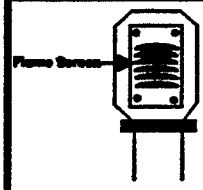
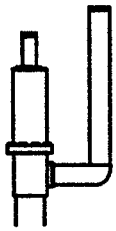
Venting Systems (cont.)

When tank vessels carry dangerous grades of cargoes, you will see vent pipes (called a riser) high above the deck of the vessel. These vent pipes will be fitted with a PV relief valve or a SR valve at the top of the riser. The primary reason for this is for the safety of persons on board and around the venting systems. When a tank vents, the vapor concentration being vented may be harmful. Vapors vented at higher levels allow for more disbursement of the vapor thus reducing its concentration before persons may be affected by it.

Illustration

The following illustration shows the three types of venting systems commonly found on tank vessels.

VENTING SYSTEM	PURPOSE	NORMALLY FOUND ON VESSELS CARRYING
 GOOSENECK VENT	Provides constant venting of vapors to and from cargo tanks.	Combustible liquids, Grades D and E
 PV RELIEF VALVE	Maintains constant pressure in tanks: – when loading or off–loading cargo – when transporting cargo	Flammable liquids Grades A, B, and C
 SR VALVE	Protects cargo from over pressurization.	Pressurized cargo

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Gauging Systems

In order to measure how much cargo is in a tank vessel's cargo tank, the tank is "gauged." There are three primary gauging methods used. These methods are called:

- open gauging
- restricted gauging
- closed gauging

The **open gauging** method involves inserting a weighted measuring tape into the cargo tank through an ullage hole. When the tape hits the bottom of the tank, the tape is retrieved and the measurement recorded.

The **restricted gauging** method is similar to the open gauging method. The difference is in the size of the opening. In restricted gauging, the tape is passed through a sounding tube rather than a normal ullage opening. The sounding tube is much smaller than the ullage opening. This permits less of the cargo vapors to escape to the atmosphere.

The **closed gauging** method may use a computer, sight glass, or similar method. When taking closed gaugings, the cargo tanks are never opened. This method prevents cargo vapors from escaping to the atmosphere.

Cargoes that have dangerous characteristics, such as those containing benzene, are the ones which would require the use of either the restricted gauging method or the closed gauging method to measure cargo amount. Cargo gauging is done by authorized vessel personnel who are properly trained to conduct the required gauging methods discussed in this lesson.

Firefighting Systems

Fire and explosions are of major concern on board tank vessels that carry large quantities of flammable or combustible liquids. This is why tank vessels must carry on board or be constructed with firefighting equipment.

Tank ships require more firefighting equipment than tank barges. Tank ships are required to be equipped with a fire main system which receives water pumped from the sea and delivers it to fire hydrants strategically located throughout the vessel.

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Firefighting Systems (cont.)

The fire hydrants must be equipped with:

- fire hoses
- firefighting nozzles and applicators
- spanner wrench

This equipment is used to deliver firefighting water from the hydrant to the fire.

Many tank ships are also equipped with fire monitors which are strategically placed on the deck of the vessel. These monitors can deliver large quantities of water or foam to fight deck fires.

Tank ships are also equipped with a fixed carbon dioxide (CO_2) system. This system uses CO_2 to extinguish fires in spaces by flooding the space with large quantities of CO_2 gas. Spaces normally connected to this system for possible flooding are:

- engine room
- pump room

Finally, tank vessels (ships and barges) are equipped with some type(s) of portable or semi-portable fire extinguishers. The amount and type of portable or semi-portable fire extinguishers required on board tank vessels is based on the vessel type and the location or spaces on board the vessel.

Inert Gas Systems

Many tank vessels have inert gas systems installed. The purpose of this system is to prevent a fire or explosion by limiting the amount of available oxygen in a cargo tank. This is accomplished by filling and maintaining the cargo tank with an inert gas (e.g., carbon dioxide, nitrogen).

An inert gas is a gas that will not support combustion (i.e., burning) and will not react with the cargo in a tank.

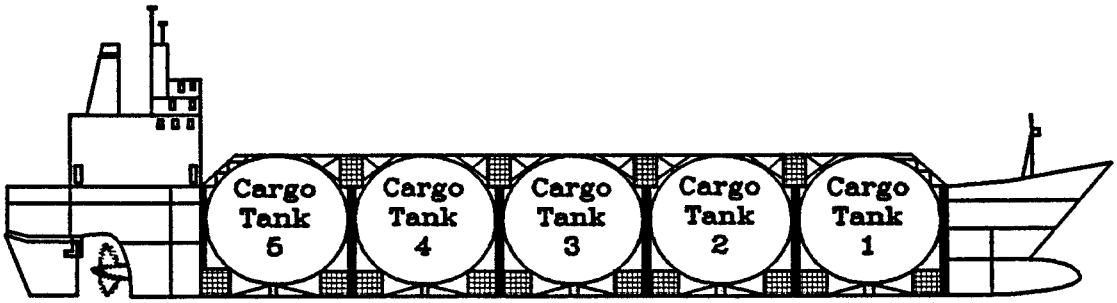
LNG/LPG CARRIERS

Introduction

Liquefied natural gas (LNG) and liquefied petroleum gas (LPG) carriers are designed to carry natural or petroleum gas which has been cooled to approximately –200°F or compressed into a liquid state to reduce its volume.

Illustration

This is an illustration of the tank arrangement on a LNG or LPG vessel.



Cargo Tanks

The cargo tanks on a LNG/LPG vessel are constructed as independent tanks and are heavily insulated for carriage of low temperature cargoes. Void spaces within the hull surround the cargo tanks which have been mounted onto supporting web frames. The void spaces contain vapor detection and ventilation equipment to prevent the buildup of flammable and toxic vapors.

Since LNG and LPG are pressurized and carried at extremely low temperatures, their cargo tanks can not be constructed of conventional steel because they will lose their impact resistance and crack easily under stress. Cargo tanks used for carrying LNG or LPG are usually constructed of:

- stainless steel
- high nickel steel
- aluminum alloy

Cargo tanks containing LNG or LPG are either spherical of prismatic in shape. These tanks are also constructed to allow for thermal expansion and contraction and are provided with appropriate relief valves which protect them from over– or under–pressure.

Self Quiz 2

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